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PNL-SA-XXXXX

ASME SUBSECTION ISTD RECOMMENDATIONS BASED UPON NPAR SNUBBER AGING RESEARCH RESULTS

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November 1991

Submitted to the
ASME Subsection ISTD Working Group
at the December 3, 1991 Meeting in
St. Petersburg Beach, Florida

Work supported by the
U.S. Nuclear Regulatory Commission
under Contract DE-AC06-76RLO 1830
NRC FIN B2911

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CONTENTS

ABSTRACT

As a result of information obtained during the U.S. Nuclear Regulatory Commission's (NRC) Nuclear Plant Aging Research (NPAR) Program, Snubber Task research, recommendations are made in the three following areas for the next revision of the American Society of Mechanical Engineers (ASME) Operations and Maintenance (OM) Code, Subsection ISTD:

- Service-Life Monitoring
- Visual Examination Attributes
- Failure Grouping and Corrective Action.

SERVICE-LIFE MONITORING RECOMMENDATIONS

Service-life monitoring recommendations were developed from the results of the NPAR research. Major recommendations are highlighted below for consideration in the next revision of the ASME OM Code, Subsection ISTD (Section 8.0 and Appendix F).

It should be noted that suggestions pertaining to service-life monitoring include a number of recommendations for testing in addition to those requirements specified in ISTD, Section 7.0. Such testing includes trending tests, diagnostic tests, and post-service as-found tests. If such tests are included in ISTD, a statement should be included to specify that the results of such tests will not require testing of additional snubber samples in accordance with ISTD Section 7.9 or 7.12.

DETERMINATION OF SNUBBER FAILURE OR DEGRADATION CAUSES

A service-life monitoring program will be most effective if it distinguishes between service-related and nonservice-related failures. It is important that the root cause of snubber failure or degradation (e.g., dynamic transient, vibration, excessive temperature, etc.) be identified along with the failure mode (e.g., high drag force, low activation, etc.) and the failure mechanism (e.g., deformation of screw or ball shaft, solidification of grease, etc.). This information provides the basis to take effective countermeasures.

It is suggested that failure evaluation data sheets provide key information, including failure mode, failure mechanism, failure cause, environment, service time, abnormal conditions, visual observations, test data, test observations, etc.

It is important that personnel involved in failure evaluation have adequate experience and training to identify failures and trace them to their root causes. Failure evaluation data sheets should not be formatted in a manner that might lead the examiner to a potentially incorrect failure cause.

Table 1 lists typical irregularities that may be observed during visual examination or during snubber disassembly that characterize features of snubber degradation and may be useful to pinpoint the potential cause.

TABLE 1. Typical Indicators of Snubber Degradation

Indicator	Possible Cause
Dark hydraulic fluid	High amplitude vibration
Gelation of fluid	High amplitude vibration
Black material deposit on rod	High amplitude vibration
Excessive piston and cylinder wear	High amplitude vibration
Worn capstan spring tangs	High amplitude vibration
Localized ball screw fretting	High amplitude vibration
Unsymmetrical wear of clevis pins	High amplitude vibration
Elongation of attachment holes	High and/or low amplitude vibration
Loose fasteners	High and/or low amplitude vibration
Symmetrical wear on clevis pins	Low amplitude vibration
Discoloration of metallic parts	Excessive temperature
Hardened piston rod wiper	Excessive temperature
Rod wiper adhered to piston rod	Excessive temperature
High compression set	Excessive temperature
Cracked seal	Excessive temperature
Lack of fluid pigmentation	High radiation level
Corrosion of metallic parts	High humidity/leaking components
Bent piston rod or attachments	Overloading
Changes in cold/hot position setting	Increased drag or jamming

DETERMINATION AND DOCUMENTATION OF THE OPERATING ENVIRONMENT

Service-life monitoring techniques take into consideration the capability of the various snubber models to endure the full range of plant environments (benign to severe). Previously unidentified severe environments may often be identified by root cause evaluation of failed or degraded snubbers. Information regarding the snubber endurance capability is often obtained from operating experience (i.e., from failure data or by monitoring degradation).

Determination of specific environmental information often involves specialized instrumentation and equipment that would be impractical for use at every snubber location. The use of such equipment, therefore, would be most practical for those applications where moderate to severe environments are anticipated or as a diagnostic aid in determining the cause of snubber degradation.

Various methods and equipment used for measurement of specific environmental parameters are described below.

Temperature

Temperature sensitive tape is useful for identifying hot spots. Ideally, however, to monitor environmental temperatures, a time/temperature profile is most useful. Chart recorders or digital data acquisition systems (e.g., bit loggers, computers, etc.) are valuable for this purpose, but obviously must be applied selectively to monitor more severe conditions in relatively large snubber populations.

Radiation

Normal radiation levels in operating plants do not usually contribute significantly to snubber degradation. Data pertaining to plant radiation levels can generally be obtained from health physics area surveys. Measurement of radiation levels specifically for service-life monitoring does not seem justified, except in cases of snubber degradation where other potential causes have been ruled out, and where radiation levels may be abnormally high.

Vibration

A number of methods and equipment for detecting and measuring vibration are available. They include simple visual observation, detection by "hands on" inspection, portable vibration measuring instrumentation, and remote vibration measuring equipment. Vibration can often be identified during routine snubber visual examination or during failure evaluation. Characteristics such as metal filings, darkened hydraulic fluid, deformed connecting pins, elongated attachment holes, and fretting of mating parts are indicators of vibration.

Transients

As with vibration, dynamic load transients that exceed the snubber load capacity may often be identified during routine inspections (e.g., observation of deformed structural members), augmented inspections (e.g., during hand-stroking of the snubber), and failure evaluation (e.g., deformed internal parts). In-situ devices, such as load measuring clevis pins, are also available to monitor snubber load in applications where such transients are suspected.

INSERVICE TESTING RESULTS

Evaluation of time traces (e.g., load and velocity) obtained during routine functional testing is useful in identifying degradation that could lead to functional failure if not corrected. For example, an unusual number of load spikes may indicate dirt or other solid particles in the snubber; a single load spike may indicate local fretting of the ball screw. Follow-up diagnostic tests (see below) are useful for further evaluating such anomalies.

DIAGNOSTIC TESTING

Diagnostic tests may be used to obtain information beyond that available from routine functional test data. Such information may be helpful in identifying the failure or degradation mechanism. For example, a progressive decrease in the "bleed" velocity of a hydraulic snubber during a sustained load can be indicative of particulate contamination of the hydraulic fluid. Test equipment used for diagnostic tests should be configured to allow the application of various levels of controlled test parameters, such as load and velocity.

AS-FOUND TESTING

Considerable information can be obtained by conducting post-service tests on snubbers removed from service. Such "as-found" tests can identify snubber degradation before failure occurs and can also identify previously unidentified severe operating environments.

TRENDING

Trending is a useful tool to monitor progressive snubber degradation. To develop meaningful trending data, a number of important factors should be considered:

- The establishment of baseline data is essential for trending.
- Trending data should be sufficiently accurate so that trends may be identified.
- Trending parameters should relate directly to the anticipated aging failure mode. Such parameters include, but are not limited to, drag force for mechanical snubbers and seal compression set for hydraulic snubbers.

  Note: An important example of inappropriate monitoring parameters is the use of functional test data for monitoring or trending seal degradation. Although seal degradation can affect functional test results to some extent, loss of low pressure sealing integrity--the primary aging failure mode for snubber seals--would not be reflected in functional test data.

- If test data are to be used for trending, it is recommended that the data be obtained consistently by using the same test machine, under the same test conditions. Ideally, the same snubber should be tested. Snubbers selected for trending should be representative of the service environment related to the snubber population to be monitored.
- Reservoir fluid level is the most appropriate trending parameter for monitoring snubber leakage.
- Trends in average drag force are generally more detectable and meaningful than for peak drag force.
- A number of plants have established administrative limits for functional test parameters in order to prompt the replacement or repair of a given

snubber before failure. This approach assumes that the parameter in question (e.g., drag force) is progressing toward the failure limit, which may or may not be the case. It is therefore recommended that administrative limits be established at a level that is outside the range of normal variations for the given parameter. Premature replacement or maintenance can increase the probability of snubber failure by introducing potential maintenance or manufacturing defects and reduce the potential benefits of the trending analysis.

AUGMENTED SURVEILLANCE METHODS

Various "hands-on" methods may be used to identify snubber degradation and to detect severe environmental conditions. These include hand stroking for verification of free movement, rotation of the snubber about its spherical bearings as a check for jamming, hand detection of vibration, and hand detection of high temperature.

Methods and equipment can be used to monitor snubbers periodically or continuously for service stressors and degradation. The snubbers can be monitored either individually or on a system basis. In situ monitoring can be used to confirm design loads and to help in the analysis of problem snubbers located in severe environments. Stressors commonly monitored are load, vibration, and temperature. Snubber stroke positions can also be monitored to verify thermal movements.

SERVICE-LIFE CATEGORIES

Depending upon the significance of environmental extremes from one area in the plant to another, separate and distinct service-life populations may be practical. For example, it may be practical to establish a separate service-life population for snubbers in the upper level of the dry well for some BWR plants, due to relatively high temperatures in that area that may result in more rapid seal degradation. On the other hand, isolated applications involving very severe environments (e.g., steam tunnel, pressurizer cubical, etc.) should be managed separately on a case-by-case basis.

VISUAL EXAMINATION ATTRIBUTES

Many attributes that should be included in snubber pre-service examinations need not be checked again during inservice examination. Snubber characteristics that are potential indicators of inoperability, e.g., empty reservoir, missing clevis pin, etc., are normally evaluated during ISI. For service-life monitoring, characteristics that relate more to degradation prior to failure are emphasized. It is, therefore, recommended that Appendix B (Recommended Examination Checklist Items) be divided into three basic checklists: one for pre-service examination only, another for inservice and pre-service examination, and another for service-life monitoring.

RECOMMENDED EXAMINATION CHECKLIST ATTRIBUTES (PRE-SERVICE EXAMINATION ONLY)

It is recommended that snubbers be visually examined for the following unacceptable attributes during pre-service examination only:

- snubber installed with preset locking screws (used for shipment only)
- snubber installed in wrong location
- protective coverings or shipping plugs not removed
- snubber freedom of movement impaired by interference with adjacent equipment
- other one-time pre-service checks recommended by the manufacturer.

RECOMMENDED EXAMINATION CHECKLIST ATTRIBUTES (PRE-SERVICE AND INSERVICE EXAMINATION)

Visual examination attributes that may indicate snubber inoperability during pre-service and inservice examinations are listed below:

- non-pressurized reservoir oriented such that hydraulic fluid cannot gravitate to snubber
- severe corrosion or solid deposits that could impair snubber performance
- inadequate swing clearance
- paint on piston rod (could cause a frozen condition)

- deformed structural attachment or piston rod
- inadequate reservoir fluid level
- clevis pin not installed
- weld arc strikes, weld slag, adhesive, or other deposits on piston rod or support cylinder (could cause a frozen condition)
- loose or missing fasteners
- cold or hot position setting varies from specified value on approved drawing
- spherical bearing not fully engaged in attachment lug.

RECOMMENDED EXAMINATION CHECKLIST ATTRIBUTES (SERVICE-LIFE MONITORING)

Typical attributes that should be noted for service-life monitoring purposes are as follows:

- evidence of corrosion
- evidence of solid deposits (e.g., boric acid) from leaking components
- loss of hydraulic fluid since previous visual examination
- metal filings on or in the vicinity of the snubber
- observed fluid leakage
- evidence of significant dark (i.e., black or dark brown) material deposit on piston rod
- rod wiper adhered to piston rod
- abnormal color of hydraulic fluid
- wear or deformation of clevis pins
- elongation of attachment holes
- evidence of wear on support cylinder
- evidence of snubber used as a stepping support
- cracked or deformed fluid reservoir

- evidence of foreign material (e.g., water, solid particles, etc.) in hydraulic fluid
- discoloration of metallic parts due to heat.

FAILURE GROUPING AND CORRECTIVE ACTION

Subsection ISTD currently requires that any snubber that fails to meet functional test acceptance criteria be classified into one of six Failure Mode Groups (FMGs) (see Figure 1). Depending on the FMG, various alternatives for corrective action may apply.

The following recommendations pertain to the classification of failures and follow-up corrective action.

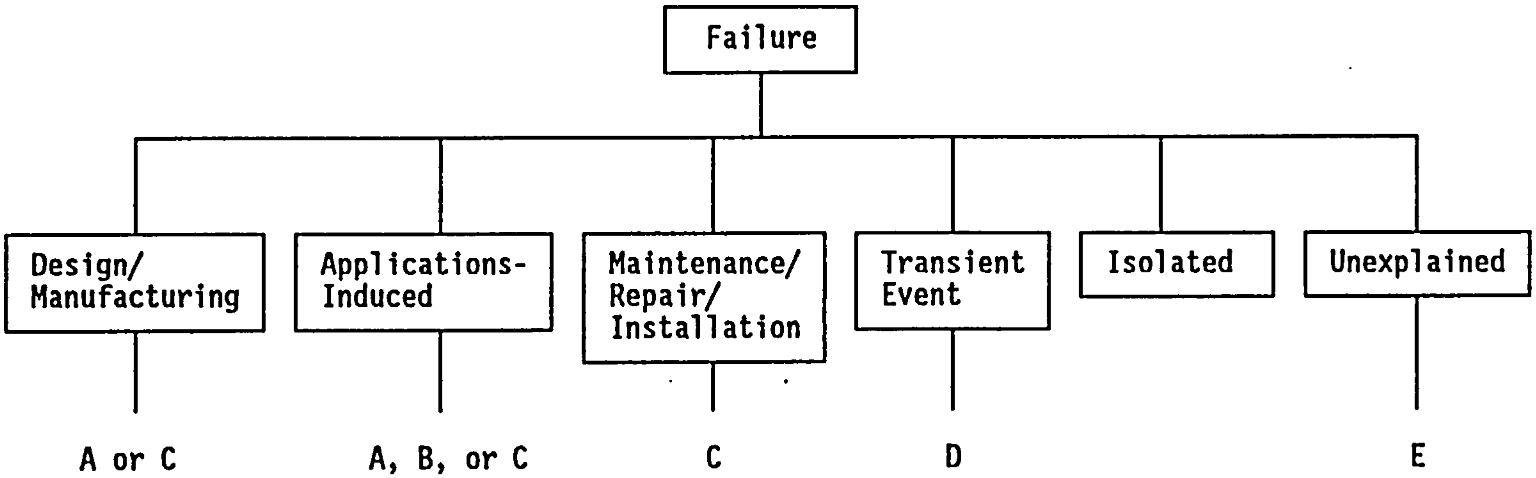
DEFINITIONS

It is recommended that the following definitions be included in Subsection ISTD. These definitions are consistent with those proposed by the Technical Committee on Common Aging Terminology (CAT):

- Failure Mode: The manner in which the snubber failed (e.g., high drag force, high acceleration, high bleed rate, low locking velocity, etc.).
- Failure Mechanism: The physical process which resulted in failure (e.g., deformation of screw shaft, thermally-induced compression set, etc.).
- Failure Cause: The circumstances during design, manufacture, or use which led to failure (e.g., excessive temperature, defective plating process, vibration, side loading, etc.).
- Root Cause: The fundamental reason(s) for failure which, when corrected, prevents its recurrence.

ELIMINATION OF ISOLATED FAILURES

By definition, isolated failures can not represent a group. It is, therefore, recommended that the isolated FMG be eliminated. Isolated failures will be addressed in the root cause category.



A: Replace all FMG snubbers with compatible snubbers; no additional testing.
B: Change the environment; no additional testing.
C: Additional testing in FMG.
D: Test or stroke all FMG snubbers; no additional testing.
E: Continue testing in sampling plan.

FIGURE 1. Current Failure Categorization and Corrective Action

DISTINCTION BETWEEN SERVICE-RELATED AND NONSERVICE-RELATED FAILURES

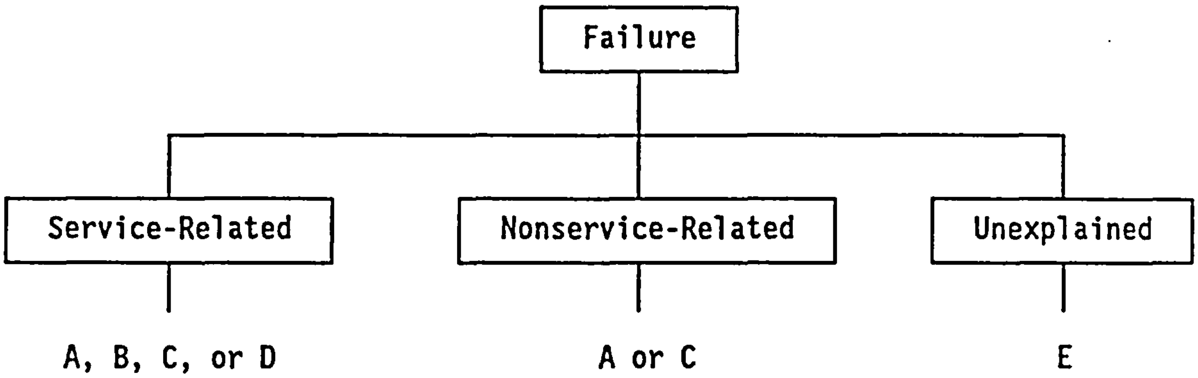
A snubber failure that is associated with a manufacturing or design deficiency could nonetheless be service related. For example, the root cause for a seal failure which results from the inadvertent use of a seal material that is less resistant to heat than the material specified by the manufacturer, may be identified as inadequate material control (a manufacturing related failure cause). Although the seal may not have endured for as long as one manufactured from the specified material, it is likely that it did provide some amount of service prior to failure. The option should be allowed, therefore, for continued use of additional snubbers that may utilize this material, provided that the environment is adjusted to be compatible with the seal material.

Snubbers with a potential for failure from the same root cause should be assigned to the same root cause groups (RCG), in order to take steps that would reduce the potential for failure during future operation. However, in order to determine which ISTD followup[a] actions are applicable, it need only be determined whether or not the failure is service-related, nonservice-related, or unexplained (see Figure 2). Therefore, it is probably not necessary to pre-establish failure cause groups in Subsection ISTD.

Categorization using the snubber-grouping plan in Figure 2 would distinguish between service-related and nonservice-related failures. This is important for two reasons:

1. to monitor the rate of occurrence of service-related failures
2. to provide the additional followup activity to modify the environment for all snubbers subject to service-related failures. (This is currently allowed for "applications induced" failures only.)

(a) Currently referred to in ISI as "corrective action."



A: Replace all RCG snubbers with compatible snubbers; no additional testing.
B: Change the environment; no additional testing.
C: Additional testing in RCG.
D: Test or stroke all transient event snubbers; no additional testing.
E: Continue testing in sampling plan.

FIGURE 2. Proposed Failure Categorization and Corrective Action

Resulting data would facilitate the compilation of useful failure statistics, both plant-specific and for the industry in general, and would allow flexibility in establishing various RCG cause categories in an industry data base without concern over conflict with ISTD.[a]

By comparing Figures 1 and 2, it can be seen that followup actions associated with the proposed classification system are consistent with those currently in the ISTD standard. One change, however, is that the option to replace, modify, or repair all snubbers in the RCG without requiring additional testing would be allowed for all failures. This option was previously allowed only in the maintenance/repair/installation failures category.

REPLACEMENT OR MODIFIED SNUBBERS

Snubbers are occasionally subject to operating environments for which they have not been qualified. Such environments include dynamic load transients, high amplitude vibration, high temperature, etc. Paragraph

(a) The Snubber Utility Group (SNUG) has encountered difficulties in establishing failure categories for the SNUG data base due to potential inconsistencies with FMGs currently included in ISTD.

ISTD 1.11.1 of the standard requires that replacement or modified snubbers have a proven suitability for the application or environment. Because environmentally compatible snubbers are not available for all such applications, utilities often have no alternative but to continue to use the same snubber model or another unqualified model.

It is suggested, therefore, that some flexibility be provided in ISTD 1.11.1 that would allow for continued use of existing snubber models in such cases. Conduction of augmented inspections for these applications would increase the probability that snubbers would be replaced or maintained prior to failure.